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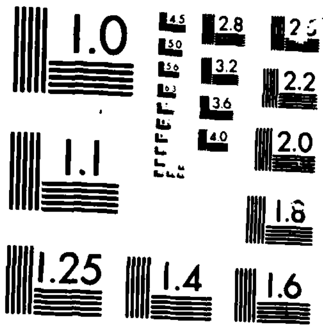

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A PROPOSED MINIMUM SAFETY CRITERIA FOR EQUIPMENT USED TO TEST BRIDGEWIRE CONTINUITY OF ELECTRO-EXPLOSIVE DEVICES

by
Mitchell A. Guthrie

DECEMBER 1985

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TO ENSURE A GREATER LEVEL OF RELIABILITY AND SAFETY IN THE USE OF ELECTRO-EXPLOSIVE DEVICES (EEDs), IT IS NECESSARY TO MEASURE THE CONTINUITY OF THE DEVICE'S BRIDGEWIRE. HOWEVER, THE ELECTRICAL EQUIPMENT USED TO MEASURE THESE PARAMETERS IS SOMETIMES CAPABLE OF CAUSING PREMATURE DETONATION OF THE EED OR DESENSITIZATION OF THE IGNITER RESULTING IN A DUD. THIS REPORT DESCRIBES MINIMUM DESIGN CRITERIA PROPOSED FOR ELECTRICAL EQUIPMENT THAT CAN BE USED TO SAFELY TEST THE EEDs.

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A PROPOSED MINIMUM CRITERIA FOR EQUIPMENT

USED TO TEST BRIDGEWIRE CONTINUITY OF

ELECTRO-EXPLOSIVE DEVICES

BY

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ABSTRACT

To ensure a greater level of reliability and safety in the use of Electro-Explosive Devices (EEDs), it is necessary to measure the continuity of the device's bridgewire. However, the electrical equipment used to measure these parameters is sometimes capable of causing premature detonation of the EED or desensitization of the igniter resulting in a dud. This report describes minimum design criteria proposed for electrical equipment that can be used to safely test the EEDs.

CONTENTS

SECTION 1

INTRODUCTION

The Navy currently uses several different devices to test the bridgewire continuity or bridgewire resistance of its inventory of Electro-Explosive Devices (EEDs). Many of these devices have been approved for use by the Naval Sea Systems Command (NAVSEA 06H) based on a safety evaluation of the instrument. For the most part, approval for use on specific EEDs has been handled on a case-by-case basis.

This paper describes safety criteria that the Naval Surface Weapons Center (NSWC) considers to be the minimum acceptable for use in the design and evaluation of bridgewire continuity testers. It is intended to promote uniformity of practice for those skilled in electrical safety evaluations.

In addition, NAVSEA has indicated an interest in the development of a military standard on this subject. This paper offers considerations for some of the requirements of this military specification. The standard would enable equipment manufacturers to consider electrical safety in the design phase rather than redesign their equipment after it is on the market. This would result in a saving of time and money for the manufacturer and the government. When the evaluation and reporting techniques are standardized, the safety evaluation of the instrument could become the responsibility of the manufacturer and could easily be checked by the purchasing activity.

SECTION 2

RELIABILITY TESTING OF EEDs

The bridgewire of an EED serves as an electro-thermal transducer, converting electrical energy into thermal energy in the form of heat. A primary explosive, such as lead azide or PETN, deposited on the bridgewire is initiated when this thermal energy reaches the initiating energy required by the explosive.

Proper operation of the bridgewire is the most critical factor in the reliable functioning of the EED. Therefore, evaluation of the bridgewire region is the most productive method used to predict the performance of an EED. However, the test procedure used to evaluate the bridgewire region must not heat the bridgewire to the ignition temperature of the primary explosive, or detonation may occur. The simplest and most common method used to evaluate operational reliability of the bridgewire is to measure its DC resistance.

SECTION 3

GENERAL EVALUATION REQUIREMENTS

NAVSEA OP-5 specifies that electrical equipment used to test the reliability of an electro-explosive device must be approved by the Naval Sea Systems Command prior to its use. This equipment must also comply with the minimum requirements of the National Electrical Code, Article 500 if testing is conducted in a hazardous location.

Prior to approval, the equipment must be examined for possible hazardous conditions due to:

1. Equipment design;

2. Environment in which equipment is being used;

3. Maintenance and test plans;

4. Standard Operating Procedure (SOP) for Explosives Testing; and

5. Potential electrostatic hazards created.

In addition, normal wear of the equipment must be considered to ensure that normal deterioration does not create a hazardous condition. Periodic testing of the equipment to ensure safe operation is recommended.

Approval of the use of test equipment for this purpose should be based on the no-fire current of the EEDs being tested. Individual approval should be granted for each explosive device being tested. However, to speed the approval process, NSWC recommends that the equipment be evaluated to determine the maximum current available from the test instrument even under multiple fault conditions. The value derived from this analysis should not exceed one-tenth of the no-fire current of the explosive device.

The equipment should be tested prior to its use to ensure that obvious faults in the functioning of the device will be detected. This testing should ensure, primarily, that the test current produced at the terminals of the equipment (for each range) is below the limit specified for the tests. The device used to test these output currents should be calibrated periodically. In addition, the SOP for the explosive tests should be specified and critically evaluated to ensure that these operations are conducted in a safe manner.

A rigid maintenance cycle should be specified and adhered to. This maintenance should be performed only by personnel familiar with the device and who are aware of the safety features included in the device. Although a device may be safe to use in the application as originally designed, improper maintenance can degrade or defeat the safety features inherent in the design. Evaluation of the equipment should include documentation of the safety features provided by the equipment and the assumptions that were made during the analysis.

SECTION 4

EQUIPMENT DESIGN

The design of the equipment is the major factor that will determine whether it can be safely used to test explosive subsystems. There is currently no standard method available for use in evaluating the design of equipment proposed to test bridgewire resistances. However, the evaluation method specified by National Fire Protection Association (NFPA), CODE 493, Chapter 2-1, can be used as a guideline in making this evaluation. Additionally, the Naval Surface Weapons Center recommends that all faults that may occur which cannot be identified in the daily initial checkout of the equipment should be assumed.

When examining the design safety of the equipment, it should be assumed that all switches and other inputs are at their most unfavorable settings. Also it should be assumed that all components are at their most unfavorable tolerance values. An accurate schematic diagram of the equipment with its parts list must be on-hand for this phase of the examination. An actual sample of the equipment to validate the schematic diagram is also useful.

Any deviation between what is on the schematic versus what is found in the equipment should be documented. Any deviation of this type can be a basis for denial of approval for use. Changes made in the equipment design or packaging configuration should void any previous approval until these changes have been evaluated. It is imperative that the manufacturer of equipment used to test explosive devices maintain strict quality control standards. For this reason, only instruments designed specifically for testing explosive devices should be used. The design of general multimeters could be changed periodically to meet a changing market without the manufacturer having to notify any users of his equipment. This is less likely to occur with explosive test equipment.

The next step in evaluating the design of the proposed equipment is a complete analysis of the circuitry including everything back to the power source. Once the normal conditions have been evaluated and documented, it is necessary to determine worst-case faults. The Reliability Analysis Center in Rome, New York documents failure modes and failure rates of electrical/ electronic components and can be of assistance in selecting these faults. The selection of faults and justification for the selection should also be documented. The worst-case circuit

analysis is then performed. As mentioned previously, testing of the unit immediately before its use can eliminate the possibility of obvious faults in the unit.

The final step in the analysis of the design of the instrument is to check for inductances or capacitances in the output circuitry and test leads that may permit storage of dangerous levels of electrical energy. This energy, if it is of adequate magnitude, can be released in the form of arcing which will be hazardous in the case where explosives may be exposed.

SECTION 5

EQUIPMENT CONSTRUCTION

Construction of the equipment can also be a factor in determining its safe operation. All connectors used on the device should be keyed to ensure that they can be inserted only in the proper configuration. Asymmetrical connectors are preferred. In addition, these connectors should be labled according to their function. If more than one connector is used per device, each connector should be of a different configuration to ensure that they are not installed incorrectly.

Exposed leads or pins are subject to short circuits and should be avoided. If a connector is not used during equipment operation, it should be provided with a cap for protection.

Proper layout of the internal components of the equipment is essential. NFPA 493 provides adequate guidelines for details of internal construction. The objective is to ensure that the safety of the device is not compromised by short circuits, etc., resulting from wires or other foreign objects that may have been left inside the device during maintenance operations. This hazard can be minimized by proper encapsulation of circuit boards and compartmentalization of such things as battery packs or power supplies.

All fail-safe circuitry should be potted or sealed to prevent the possibility of being compromised by short circuit or tampering. These safety features should be clearly marked inside the enclosure.

Battery operated instruments should have a built-in current limiting device to ensure that the battery does not go into thermal runaway due to a short circuit (which in some cases could cause an explosion). This current limiting device is most effective when it is built into the battery pack. When changing batteries in these instruments, the same type battery must be used as a replacement. If the current limiting device is built into the battery pack it should be clearly labeled and it must be replaced by an equivalent pack.

The materials used in the construction of the explosives test equipment are also important. If the device is portable, there is a possibility that transport of the unit can cause generation of static electricity (if the case is made of a poor conductor). Before approval, the unit should be tested to determine if it is capable of storing dangerous levels of

electrostatic energy. The use of sealed keyboards, low-powered Complementary Metal Oxide Semiconductor (CMOS) circuitry, and liquid crystal displays can enhance the safety of the device.

SECTION 6

CONCLUSIONS AND RECOMMENDATIONS

The use of modern electronic equipment to test the operational reliability of electro-explosive devices is recommended. However, this equipment must be approved prior to its use. The Naval Surface Weapons Center recommends that a standard method be devised by which this equipment can be evaluated. The documentation required by this standard would permit the approving agency to make a more valid evaluation of the risks associated with the use of these instruments for any given application. Also, it should decrease the amount of time necessary for approval. The overall advantage would be a saving of time and money in the approval process for electrical equipment used to test the bridgewire resistance of electro-explosive devices.

BIBLIOGRAPHY

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Brauer, K. O., Handbook of Pyrotechnics, New York: Chemical Publishing Co., 1974.

Chetly, B. A., and Devanathan, R., "Analysis of the Application of and Promotional Measures Needed for Electronic Instrumentation in Hazardous Locations," Electronics - Information and Planning. Vol 5, No. 7, April 1978: 496-540.

Doyle, E. A., "How Parts Fail." IEEE Spectrum, October 1981: 36-43.

Military Specification, "Initiators, Electric, General Design Specification For." MIL-I-23659C, 31 August 1972.

National Fire Protection Association, "Intrinsically Safe Apparatus." NFPA Code 493, Quincy: National Fire Protection Association, 1977.

National Fire Protection Association, "The National Electrical Code." NFPA Code 70, Quincy: National Fire Protection Association, 1981.

Naval Surface Weapons Center, "Safety Analysis of Space Electronics Model 101-5RZ Igniter Circuit Tester," NSWC ltr N42:MAG:rsm 8020, 29 March 1982.

Rosenthal, L. A., "Heat Capacity Measurement Method for Bridgewires." Review of Scientific Instrumentation, Vol 45, No. 12, December 1974: 1523-7.

Rosenthal, L. A., and Menichelli, V. J., "Nondestructive Testing of Insensitive Electro-explosive Devices by Transient Techniques," Materials Evaluation, January 1972: 13-19.

Small, J. B., and Savilla, D., "Improved Equipment for Electrical Testing of Rounds with M509 Fuze (Phase I)," Picatinny Arsenal Tech Report DE-TR:9-58, October 1958.

Stiffler, J. J., "How Computers Fail," IEEE Spectrum, October 1981: 44-6.

Thompson, R. H., "Investigation of the Electrical Breakdown Characteristic of An Explosive," Franklin Institute Technical Report FIRL-F-C4145, February 1976.

BIBLIOGRAPHY (Cont)

Urbanski, T., and Vasudeva, S. K., "Explosions and Explosives: Fundamental Aspects," Journal of Scientific and Industrial Research, Vol 40, August 1981: 512-19.

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